A MODEL OF THE RADIO EMISSION OF URANUS

by

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At the present time many experimental data have been accumulated concerning the radioemission of Uranus [ref. 1-7]. A characteristic property of the radioemission of this planet is the considerable excess of the measured brightness temperatures above the calculated equilibrium temperature of the planet caused by solar heating. Qualitatively, this property is apparently caused by the thermal radiation of the atmosphere, the temperature of which increases with the depth. However, there has to date not been any quantitative model which corresponds to the experimental data. In this note a model of the radioemission of uranus is examined which corresponds to the radioastronomical and optical data of this planet.
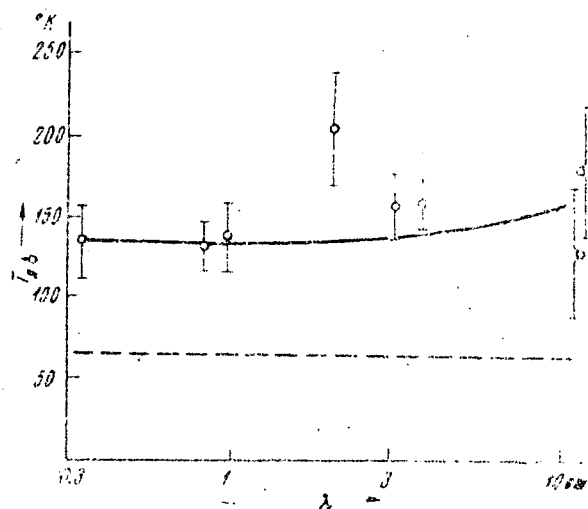

Fig. 1

The investigation was conducted under the following initial parameters and hypotheses:

1. The basic component of the atmosphere is molecular hydrogen ($\mu = 2$, $c_p = 3.44$ cal/g deg, $c_p/c_v = 1.40$).

2. The temperature and pressure of the atmosphere at the formation level of the H_2 and CH_4 lines are equal to 55 K and 3 atm [ref. 8]. Below this level the atmosphere is adiabatic with the gradient $\beta = Ag/c_p = 2/3$ deg/km.

3. The mechanism of emission is thermal. The brightness temperature and its dependence on the wavelength are determined by the emission transport equation.

4. The absorption of superhigh frequencies of the emission is caused by gaseous ammonia the relative content of which corresponds to saturation [ref. 9].

5. The coefficient of absorption in NH_3 is determined by the high-ressure formula [ref. 10]

$$\gamma = \frac{4\pi n_{NH_3}\mu^2}{2ckT}\frac{\omega^2\theta}{1+\omega^2\theta^2},\qquad (1)$$

where n_{NH_3} is the number of ammonia molecules per cubic centimeter, $\mu = 1.49 \cdot 10^{-18}$ is the dipolar moment, c is the speed of light.

6. The results of the measurements of the absorption in NH_3 at high pressures [ref. 11] are the basis for determining the frequency of collisions $\Delta\nu = 1/2\pi\theta$; these results have shown that at pressures greater than 2 atm $\Delta\nu/p = 0.21$ cm^{-1} ·atm^{-1}. In connection with the fact that according to measurement data [ref. 12] the effective collision cross section of a mixture of NH_3 with hydrogen is 16 times less than for pure NH_3, customarily $\Delta\nu = 0.013\, p$ cm^{-1}.

For the development of the frequency dependence of the coefficient of absorption, the relationship (1) was presented in the form:

$$\gamma(\omega) = \gamma(\infty)a(\omega)$$

where

$$\gamma(\omega) \approx \frac{4.7 n_{NH_3}\mu^2}{3ck T}\frac{1}{\Theta} \approx 0.55\frac{p^n_{NH_3}}{T}$$

$$a(\omega) \approx \frac{\omega^2 \Theta^2}{1+\omega^2\Theta^2}$$

Here γ is expressed in km^{-1}, and p in atm.

The results of the calculation are shown in Figure 1 with the brightness temperature T_b as a function of the wavelength λ of the radioemission received. This same figure shows the results of the radioastronomical measurements [ref. 1-7]. The equilibrium temperature of solar heating for the planet is shown by the dotted line.

The good agreement of the calculation with the measurements $T_b(\lambda)$ benefits the presence of* gaseous ammonia in the atmosphere of Uranus at saturation temperature and, consequently, aerosols of heavy ammonia. Note that the relative content of gaseous ammonia at the level of formation of the H_2 and CH_4 lines is in the assumed model 10^{-14}, which agrees with failure of the attempts of spectral detection of NH_3.

The indicated model, examined above for Uranus, also agrees satisfactorily with the results of the radioastronomical measurements of Neptune [ref. 3, 5, 7]. This speaks in favor of the similar chemical composition and temperature profile of the atmospheres of these planets.

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